

PRACTICAL DESIGN GUIDELINES FOR REPLACEMENT OF DEFICIENT BRIDGES
WITH LOW-WATER STREAM CROSSINGS IN THE RURAL MIDWEST

by

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Practical Design Guidelines for Replacement of Deficient Bridges with Low-Water Stream
Crossings in the Rural Midwest

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Abstract

The use of a low-water crossing may be an economically viable option to replace a structurally deficient or functionally obsolete bridge. Rural counties generally cannot afford to replace all deficient bridges and must prioritize their expenditures. In many locations the traffic volume is too low to justify the expense of bridge replacement. This situation is worsening as the rural population declines. Some counties are closing low-volume roads rather than replacing deficient bridges. In some locations a low-water stream crossing might be a practical low-cost alternative to road closure.

This thesis provides guidance to county officials and engineers on assessing the practicality of replacing a deficient bridge with a low-water crossing and selection of the best type of crossing. This report investigates several different types of low-water stream crossings and their usefulness in Kansas. A site assessment procedure is provided to rule out any type of low-water stream crossing that would be inadvisable in a particular location. A preliminary investigation and consultation with applicable permitting agencies and which type of permit to obtain for low-water stream crossing projects is outlined in this report. Guidance on designing a low-water stream crossing is included. Nine case studies of five different types of low-water crossing projects in Kansas within the last ten years are thoroughly documented accompanied by a summary of their importance. A lessons-learned section summarizes useful observations collected from county officials, regulatory personnel, and engineering consultants. To conclude the report, a summary of important information regarding LWSC projects is provided.

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Chapter 1

Introduction

1.1. Background and Purpose

In rural areas of Kansas, there are many county-owned bridges that are structurally or functionally deficient and in need of replacement or closure. Counties cannot afford to replace all the deficient bridges with like structures and must prioritize their yearly expenditures. County officials are frequently faced with the choice of closing the road indefinitely, replacing the structure with a bridge that has a similar span and configuration, or replacing the old bridge with a more economical alternative such as a low-water stream crossing (LWSC).

Most land in Kansas is used for some type of agriculture. The need to repair or replace a bridge is often driven by the need to maintain or restore access to agricultural property. Multiple counties in Kansas agreed “that non-engineered low-water crossing is always considered for an alternative” (Mulinazzi et al., 2013). An “example of a LWSC candidate would be on a primitive road serving only as a field access for local farmers. During good weather conditions, a well-designed vented ford would provide adequate facilities for any traffic using the road.” Using a LWSC at this type of location “might be superior to the typical obsolete bridge found at this site.” The types of bridges found at these remote locations might be a “wood structure built just after the turn of the century” on “a narrow roadway.” These types of bridges were not designed to carry “modern farming equipment” with “widths of 18 to 20 feet” (Rossmiller et al., 1983). “Other potential locations for LWSC which may tolerate a short loss of access” are those “which

have no residences” and stream crossing structures that are not a school bus or postal route (Rossmiller et al., 1983). LWSCs are usually found in areas with “little funding for structure condition monitoring and maintenance” (Clarkin et al., 2006). Unvented fords tend to “obstruct flows less than most culverts” and can be utilized in “channels with extreme flow variations” (Clarkin et al., 2006).

There are numerous reasons to use LWSCs but the most common reason is “shortage of funds and low traffic volumes.” “The alternative to a LWSC would be no bridge at all” in some rural locations with a deficient bridge for a crossing. This type of case is commonly seen in Kansas counties and therefore using a LWSC and keeping the road open to traffic “is generally more easily accepted from a point of practical consideration and as a workable compromise” (Motayed, Chang, & Mukherjee, 1982). There are lots of variables to consider when using a LWSC and one type of LWSC may work better than others in a certain location.

This research began with a review of applicable literature. The literature review provided a basic understanding of low-water stream crossing (LWSC) issues: site selection, types of crossings, case studies, and methods for design and construction. Extensive communication was a large part of this research. Numerous engineering firms, permitting agencies, and county officials were contacted and surveyed to better understand LWSCs. The communication part of the research provided a more robust understanding of LWSCs and their purpose in Kansas. We learned of nine low-water crossing projects in Kansas that were designed, permitted and (with one exception) constructed in the last 10 years. We visited these nine crossings and document our findings in case studies.

This thesis begins by defining LWSCs. The common types of LWSCs and their usefulness in rural areas are discussed. When considering a low-water crossing, it is necessary to understand and meet the various permitting requirements. LWSCs in Kansas may require permits from the United State Army Corps of Engineers (USACE), the Kansas Department of Agriculture – Division of Water Resources (KDA-DWR), the Kansas Department of Wildlife, Parks and Tourism (KDWPT), and the local floodplain administrator. The design of a LWSC will almost always include a roadway profile and considerations of hydrology, hydraulics, and foundation requirements. The nine case studies are documented in detail. Communication with applicable parties was a large part of this research and therefore lessons learned by these representatives is included as a final chapter.

1.2. Definition

A practical definition of a LWSC “is a structure designed to allow the fording of a watercourse during periods of low flow. The structure is submerged during periods of high flow” (Wood and Cooper, 1984).

The Federal Highway Administration (FHWA) published “Design Guide: Low Water Stream Crossings” and “Design and Construction of Low Water Stream Crossings” in 1982 (Motayed, Chang, & Mukherjee, 1982). These two documents are considered to be the most thorough guidelines for the design and construction of a LWSC to date. Additionally, the U.S. Forest Service published a document titled “Low-Water Crossings: Geomorphic, Biological, and Engineering Design Considerations” which provided helpful insight on LWSC design and construction and provides numerous well-documented case studies.

After review of several informative papers and consultation with multiple county officials and engineering firms the research team at the University of Kansas developed a LWSC definition. The developed definition differs from the other LWSC definitions in that it provides a percentage chance of impassible conditions. The University of Kansas definition is: A LWSC is a structure that is designed to have at least a 50% chance of becoming impassible due to overtopping in any given year. A corresponding definition would be: A LWSC is a structure that is likely to become impassable due to flooding one or more times in a normal year. Generally this means that the roadway elevation is no higher than the tops of the streambanks. The duration of flooding over the roadway generally should not exceed one day. LWSCs are sometimes constructed to keep a road open since the initial construction cost is lower than larger culverts or bridge structures. However, the initial cost benefits of a low-water crossing should be balanced with potential long-term maintenance issues and the risk to the traveling public.

1.3. Types of Low-Water Crossings in Kansas

Three common types of LWSCs are unvented fords, vented fords, and low-water bridges. Within the last ten years, Kansas has utilized the three most common types of LWSCs as well as box culverts and bottomless culverts. The five types of LWSCs found in Kansas are described below.

- a) Unvented ford: Unvented fords are structures that are constructed flush with the streambed level. They are usually designed to have very mild approach grades. Permanent unvented fords are typically constructed of reinforced concrete and should only be used on very low volume roads. Cut-off walls of reinforced concrete or steel sheet-pile or other measures should be used to prevent undermining by the stream on the upstream and downstream sides of permanent structures.

- b) Vented ford: Vented fords are much like unvented fords but they are designed with openings below the top of the roadway that convey low flows without being overtopped. Therefore, vented fords provide access for vehicles when the stream discharge is smaller than the vent capacity. Circular, elliptical, arched, and other shapes of pipe are used as vents for the cross drainage structures. The pipes are usually made of galvanized steel, aluminized steel, reinforced concrete, or high density polyethylene (HDPE). The vents are stabilized in the structure under the deck and preferably with their flow lines set at or below the streambed level.
- c) Low-Profile Box Culverts: Reinforced-concrete box (RCB) culverts are similar to a vented ford but they usually have a larger waterway opening. Their increased conveyance makes them safer for the traveling public than a vented ford since they are less susceptible to overtopping. Box culverts use headwalls and wing walls to retain the fill supporting the roadway. The bottom is paved and with a toe wall at each end to prevent undermining of the culvert. The low-profile box culverts are like any other reinforced concrete box (RCB) but the cells are shorter in height and they are installed so the deck is below the streambank. The low-profile culvert should be embedded to promote aquatic organism passage.
- d) Low-Profile Bottomless Culverts: Bottomless culverts include three-sided box culverts and concrete or corrugated metal arches and elliptical arches with open bottoms. The difference between a conventional culvert and a bottomless culvert, from a hydraulic standpoint, is that the natural streambed material is exposed by an open bottom instead of reinforced concrete. A bottomless structure promotes aquatic organism passage better than a standard culvert or vented ford because it preserves a portion of the natural

channel. Bottomless culverts are similar to bridges because they must be placed on either a spread footing or pile foundation. Spread foundations keyed into shallow rock are more common than pile foundations for this type of structure. Bottomless culverts should generally only be used where the stream bed is composed of a very stable material such as rock. They are commonly factory-made of concrete or steel in either an elliptical arch, a round arch, or a three-sided box configuration and can be installed quickly once the foundations are in place.

- e) Low-Profile Open-Span Bridge: Low-profile bridges are usually designed to constrict flow less than a culvert but can be more expensive depending on the foundation requirements. Low-profile bridges and bottomless culverts are also similar because their road surfaces are both constructed at or below streambank height, they require pile or spread foundations, and they are more conducive to aquatic organism passage (AOP) than fords or culverts. Frequent overtopping can make these structures more susceptible to abutment scour from pressure flow conditions. For this reason, special attention should be paid to abutment and approach stabilization of the bridge abutments and the roadway approaches. Low-profile bridges are generally suitable for any streambed. Low-water bridges may be a better option than the other low-water crossing configurations for perennial streams with substantial base flow and for watersheds with larger contributing drainage areas. Debris is less likely to clog a low-profile bridge than a vented ford or a culvert.

Chapter 2

Site Assessment

Many factors must be considered before deciding to use a low-water crossing. A preliminary site assessment will help rule out inadvisable options. Low-water crossings are not an appropriate alternative to bridge replacement in some locations. Variables such as initial construction, roadway construction, traffic types and volume, stream characteristics, regulatory requirements, maintenance costs, structure lifespan, available funding, and public safety should be considered when determining if a LWSC is an appropriate structure choice. The best option for structure replacement is the option that balances all of these factors while still considering that public safety is paramount.

2.1. Traffic and Access

Low-water crossings are typically impassible for hours at a time, multiple times a year. For this reason, they should only be considered for roads with low traffic volumes where no significant increases are expected within the foreseeable future. Low-water crossings are not recommended for school bus routes, emergency service vehicle routes, or regular postal routes. Routes that provide the only access to residential, industrial, or commercial land use areas are not good candidates for low-water crossings.

The average daily traffic (ADT) on a roadway is an important factor that is used to determine whether or not a low-water crossing is feasible for a stream crossing location. Low-water crossings are most suitable for roads that have 20 ADT or less. The length of detour to get

around an overtopping crossing should be no more than 10 miles. A detour of five miles or less is preferred to discourage impatient drivers from risking their lives at a flooded crossing.

Access is a primary concern for LWSCs. By definition, LWSCs will be impassable occasionally. Since uninterrupted emergency access to residences is essential, a LWSC should not provide the only access to residences. Low-water crossings require frequent maintenance to remove trapped debris and repair any erosion damage. Maintenance activities require access for utility and construction vehicles. When selecting a site for a LWSC, the extra travel time spent to use an alternative route should be an important consideration.

2.2. Roadway Issues

Many stream crossings may not be appropriate locations for a low-water crossing because of the roadway surface or geometry. Drivers expect to be able to travel faster on a paved road than a gravel or dirt road and they are likely to be caught off guard by a flooded crossing on a paved road. Low-water crossings should not be installed on paved roads.

LWSCs can be hazardous during the winter due to ice accumulation on the approaches and on top of the structure. For safety, approach grades generally should not exceed 10%. Vehicles that lose control on the descent or ascent of one of the approach slabs or on the surface of the low-water crossing may slide into icy waters since most low-water crossings do not have guardrails.

Some roadways that approach a low-water crossing are constructed just above bankfull elevation. Since most low-water crossings are constructed with a driving surface that is below bankfull elevation, drivers who are unfamiliar with a road may not see a flooded low-water

crossing overtopping near bankfull until it is too late to stop. This is especially problematic late at night or during a storm event when there is reduced visibility.

LWSCs should be sufficiently straight and wide enough for modern farm vehicles and machinery. Warning signs are needed to alert drivers approaching a low-water crossing.

KDOT's 2005 "Handbook of Traffic Control Practices for Low Volume Rural Roads" provides guidance on appropriate signage for low-water crossings in Kansas (Russell, Mulinazzi, & Kornala, 2005).

2.3. Stream Characteristics

Streams are commonly categorized as perennial, intermittent, or ephemeral. Perennial streams flow continuously in a normal year and go dry only during periods of extreme drought. These streams have base flow even during most dry periods because they are located below the adjacent groundwater table. Intermittent streams convey base flow during certain times of the year when the adjacent groundwater table rises above the streambed. Ephemeral streams are always located above the groundwater table. They convey only surface runoff from rainfall and snowmelt. The contributing drainage area and type of stream can indicate the types of structures that are suitable at a specific location.

Certain types of low-water crossings are not the best option for some perennial streams since the continuous flow through or around the structure increases the risk of long term degradation of the structure or the adjacent bed and bank material. Large, continuous flowing rivers are harder to provide maintenance for since they are rarely dry and may be dangerous to work in.

Some streams in Kansas pose a threat to the lifespan of LWSCs with vents because they are either high in acidity or the upstream watershed has excessive cattle activity. KDOT's Metal Pipe Policy (found on their website) should be reviewed during the planning stages of the project. KDOT has a table that indicates what pipe materials can be used in each county in Kansas.

2.4. Vertical Stability of the Streambed

Wide, shallow waterways with firm streambeds are the best candidates for low-water crossings. Low-water crossings should not be placed on streams that are actively degrading. Downstream degradation can foreshadow future instability since headcuts often work their way upstream, affecting the stability of a stream crossing. Aggradation can also be problematic for low-water crossings. Siltation or aggradation on top of the structure can bury an unvented ford and take away traction from the deck of the crossing. A vented ford, low-profile culvert or low-profile bridge can also lose capacity when its waterway opening size is decreased by sedimentation within the waterway opening.

2.5. Type and Amount of Debris

The amount of woody debris that a stream carries downstream in a flood affects the choice of a structure type. Low-profile structures should be used with caution on streams that have high debris loads because frequent exposure of the structure to floating drift increases the potential to damage the upstream side of the structure and clog the vents. Clogging the waterway passage will cause the crossing to act as a dam with water flowing over the roadway. The damming effect can increase the duration of inundation, the potential for structural failure, and the costs to the general public if routine traffic has to use an alternative route.

2.6. Maintenance

Required maintenance after overtopping events is a common drawback of a LWSC. These structures should be inspected and any trapped debris should be removed after each high-flow event, regardless of whether the structure was overtopped. Flow over a LWSC can wash away the road surface, deposit debris onto the road surface or at the entrance to the vents, and possibly undermine the structure. County maintenance crews should check all low-water crossings after-high flow events and clear debris and make repairs as needed. Once the flow has subsided, county maintenance crews can decide which low-water crossings require repair of the roadbed, or the removal of trapped debris.

Chapter 3

Permitting

Stream-crossing projects require coordination with multiple regulatory agencies. This chapter provides an overview of the permits and approvals that may be needed. Some of the agency contacts and permitting requirements are specific to Kansas, but other states have similar requirements based on the same federal regulations. The U.S. Army Corps of Engineers (USACE), the Kansas Department of Agriculture's Division of Water Resources (KDA-DWR), the Kansas Department of Wildlife, Parks and Tourism (KDWPT), the Federal Emergency Management Agency (FEMA), and the Kansas State Historical Preservation Office (SHPO) are the key agencies for stream-crossing projects in Kansas. Other federal and state agencies may also provide input to permit decisions.

All LWSC projects require a Section 404 permit from USACE. Most LWSC projects in Kansas also require a stream obstructions permit from KDA-DWR. Projects that could impact threatened or endangered species or their critical habitat in Kansas also require an Action Permit from KDWPT.

3.1. Preliminary Investigation

Regulatory concerns may affect LWSC feasibility or limit design options. These concerns include issues related to threatened and endangered species, FEMA floodplain regulations, and the historical significance of the old bridge. These issues should be investigated early in the site assessment. Issues related to threatened and endangered species should be investigated by requesting a preliminary environmental review of the proposed project by the

Kansas Department of Wildlife, Parks and Tourism (KDWPT). To initiate a preliminary environmental review, KDWPT requires only the project location and conceptual sketch plans for the options under consideration. A preliminary environmental review by KDWPT early in the planning stage can help avoid problems later in the permitting process. KDWPT provides input to USACE on all Section 404 permit applications and to KDA-DWR on all stream obstruction permit applications. Any project that could adversely impact the habitat or range of habitat for a threatened or endangered species must also be issued a separate Action Permit from KDWPT.

FEMA flood maps for the project location can be accessed online through the FEMA Map Service Center when available. If the crossing site is located in a FEMA-mapped floodplain without a regulatory floodway, then the replacement of the bridge with an LWSC must not increase the 1%-annual-chance flood level by more than 1.0 foot. If the crossing is within a FEMA-mapped floodplain with a regulatory floodway, then the replacement of the bridge with a LWSC must not cause any increase in the 1%-annual-chance flood level when fill is placed within the floodway. These requirements may eliminate some or possibly all types of LWSCs from consideration.

The site assessment should also include a preliminary determination of any applicable historic preservation requirements. In Kansas, USACE in conjunction with the State Historic Preservation Office (SHPO) makes these determinations. If a structurally or functionally deficient bridge is found to have historic value, project options may be limited, and the old bridge may need to be left in place. SHPO encourages inquiries regarding possible historic resource issues during the site assessment to avoid permit-related delays and changes later.

3.2. Section 404 permit from USACE

Section 404 permits are either “general” or “individual.” Projects that cause minimal impacts to aquatic resources typically qualify for a general permit. Projects with greater anticipated impacts may require an individual permit. USACE issues three types of general permits: nationwide, regional, and state. Nationwide permits authorize activities on a nationwide basis except as specifically limited in a particular region.

The USACE has created 51 different Nationwide Permits for different types of activities that impact regulated waters. Most LWSC projects have footprints that are small enough to qualify for Nationwide Permits. LWSC projects are typically issued Nationwide Permit 14 – Linear Transportation Projects (NWP 14). This permit covers activities required for construction, expansion, modification, or improvement of roads, highways, railways, trails, airports and similar facilities in regulated waters. To qualify for NWP 14, the loss of regulated waters (typically due to fill) must not exceed one-half acre. Channel modifications such as realignment and bank stabilization must be limited to the immediate vicinity of the project and to the minimum extent necessary to construct or protect the project unless the changes are beneficial to the aquatic environment (e.g., stream restoration).

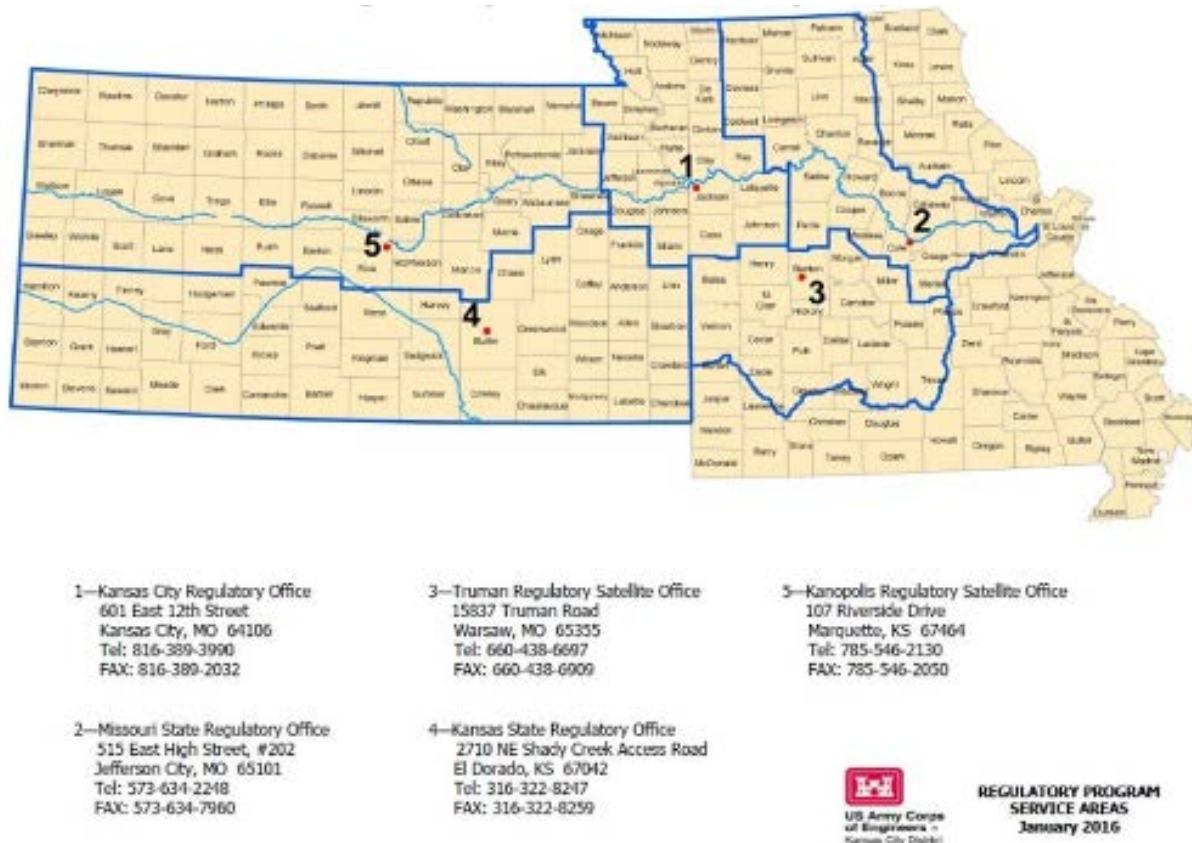


Figure 3-1: USACE Regulatory Office Boundary Map for Kansas and Missouri

3.3. Stream Obstructions Permit from KDA-DWR

By Kansas law, any construction in a “designated stream” requires a permit from the Kansas Department of Agriculture’s Division of Water Resources (DWR). A designated stream is a watercourse with defined bed and banks and a drainage area that exceeds 1 square mile in Zone 1 (as defined in Figure 3-2), 2 square miles in Zone 2 or 3 square miles in Zone 3. A DWR permit must be obtained before starting any construction in or adjacent to a designated stream. DWR permits are issued for construction of bridges, culverts, low-water crossings, dams, levees, bridges, pipeline crossings, buried cable crossings, channel changes and floodplain fill. DWR issues a General Permit for bridge and culvert replacement projects and pipeline/buried cable

crossing projects that meet certain requirements. Other projects are issued individual permits. To qualify for the General Permit, the project must meet all of the requirements listed on the General Permit Worksheet which can be found on DWR's website.

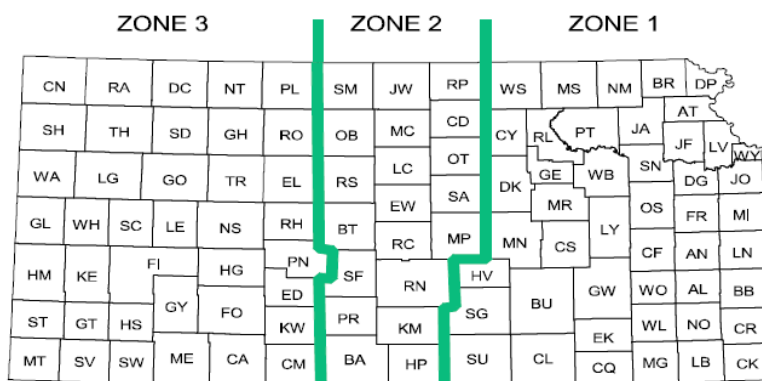


Figure 3-2: Zoning map for drainage areas in Kansas (Stream Obstructions Permit Application)

The application process for the DWR permit is similar to the application process for the Section 404 permit. The completed application form should be submitted with a location map, plan and cross-sectional drawings, any other project information relevant to the application, and the required fee payment. The staff DWR's Water Structures Program (785-564-6640) will provide assistance as needed. The permit fee for the General Permit is \$100. The fee for an individual permit for a bridge, culvert or low-water crossing project depends on the drainage area at the crossing: \$100 for 5 square miles or less, \$200 for between 5 and 50 square miles, and \$500 for 50 square miles or more.

To comply with the state's Water Projects Environmental Coordination Act (ECA), DWR sends all permit applications to seven other state agencies for review. These seven agencies are the Kansas Department of Wildlife, Parks and Tourism (KDWPT), the State Historic Preservation Office (SHPO), the Kansas Biological Survey (KBS), the Kansas Department of

Health and Environment (KDHE), the Kansas Forest Service, Kansas Conservation Commission, and Kansas Corporation Commission. These agencies may suggest ways in which projects may be modified to minimize or mitigate environmental impacts. ECA review comments on General Permit applications must be submitted within 7 days. The review time interval for the Application for Permit must be submitted within 30 days.

3.4. Action Permit from KDWPT

A KDWPT Action Permit can be required for projects that could adversely impact the habitat or range of a threatened or endangered species. KDWPT determines whether an Action Permit is needed based on the project's location and other factors. KDWPT makes this determination in its review of the DWR permit application and/or the public notice for the Section 404 permit. If informed that an Action Permit is needed, the project owner should submit a permit application as soon as possible and no less than 90 days before the intended start date for construction. Project plans and other relevant information should be submitted with the completed application form. As a general rule, permit applications are processed within 30 days of receipt. An Action Permit consists of General Conditions and Special Conditions. Every Action Permit includes General Conditions. Special Conditions are added as needed to protect specific threatened or endangered species and their critical habitat. For example, a Special Condition might prohibit construction activity during the spawning period of a particular aquatic species.

3.5. Floodplain-Related Requirements

Low-water crossing projects within FEMA-mapped floodplains are subject to additional requirements. At a minimum, a floodplain development permit must be obtained from the local (county or city) floodplain administrator prior to construction. Application procedures vary

locally. If the proposed project meets the requirements of the National Flood Insurance Program and the community's floodplain management ordinance, the permit is issued. The community's requirements may be stricter than the NFIP's minimum requirements. If the crossing location is located within a mapped floodplain with no regulatory floodway, the basic NFIP requirement is that cumulative effect of the proposed project and all other existing and anticipated development must not increase the 1%-annual-chance flood level by more than 1.0 foot at any point. If the map includes a regulatory floodway, all fill and construction within the floodway is prohibited unless the proposed encroachment would not cause any increase in the 1%-annual-chance flood level – the so-called no-rise requirement. No-Rise Certification is required for issuance of a floodplain development permit for any project that encroaches upon a regulatory floodway. The No-Rise Certification is issued by the local floodplain administrator on the basis of a detailed hydraulic study submitted by the applicant. The hydraulic study, which must be prepared by a licensed engineer, generally requires modification of the computer model used to develop the FEMA map of the floodplain and floodway. The replacement of an existing bridge with a low-water crossing could increase or decrease the 1%-annual-chance flood level, depending upon whether the new structure presents a greater or lesser obstruction to the flood flow. If the old bridge forms a significant obstruction to the regulatory flood, a well-designed low-water crossing can meet the no-rise requirement.

Chapter 4

Design

The design of a LWSC may be relatively simple depending on the type compared to conventional bridges. Any low-water crossings should be designed by a licensed professional engineer. LWSCs “are generally less expensive to construct. More often than not, designs are less complicated, construction is quicker, and fewer materials are involved” (Clarkin et al., 2006). Certain conditions can make a design more complex. Examples include, if the stream crossing is in a FEMA-designated floodway or the conditions of the soil’s subsurface requires a substantial foundation.

4.1. Roadway Profile

The roadway profile is one of the most important aspects of LWSCs. How the roadway profile is designed affects how safe the crossing is for passage. “Road approaches must ramp up to a high-profile bridge or large culvert” but the approaches for a LWSC are different. “Road approaches to low-water crossings can be low across the flood plain and generally dip down toward the stream, minimizing any impairment of flood plain processes.” Some stream crossings can be “difficult locations for low-water crossings” like channels that are “deeply incised below the adjacent ground surface and channels closely bounded by steep slopes” (Clarkin et al., 2006).

Safety is the most important concern in designing a LWSC. Signage to indicate to a driver that a LWSC is ahead and it is a flood-prone area is perhaps the first line of defense when it comes to keeping drivers safe while crossing low-water structures. Proper signage for LWSCs

in Kansas can be found in the “Handbook of Traffic Control Practices for Low Volume Rural Roads” (Russell et al., 2005). The surrounding environment should be considered before choosing a type of crossing. Because a LWSC will be flooded at times, icy waters should be taken into consideration. “Winter ice on the roadway” is a hazard “even to slow-moving traffic and [it is] especially likely on fords at the low point of the dip.” Deposition of streambed and bank material on top of fords can also be hazardous to drivers, even at slow speeds. Maintenance and routine checks can minimize these hazards. “Paving the approaches and rock the ditches” can help counteract the negative effects of erosive flood flows and increase safety (Clarkin et al., 2006).

LWSCs are generally not workable for deeply incised channels. LWSCs are best utilized in stable channels with light to moderate debris loads at high flows. “Shallow channels on wide flood plains may be good candidates for low-profile crossing structures” for this reason (Clarkin et al., 2006).

“Where practical, 10 percent is the recommended maximum approach grade.” Ideally, low-water crossings should be located where the road is straight and sight distance is good. Adequate warning signs are critical for identifying the approaching ford and warning drivers that the crossing may be flooded and have periodic traffic delays (Clarkin et al., 2006). “Approaches at either end of a low bridge is normally protected by a wing wall abutment. It keeps the approach embankment fill from spilling into the channel and holds the roadway at the bridge surface elevation” (Motayed, Chang, & Mukherjee, 1982).

4.2. Hydrology

Reasonable estimates of streamflow characteristics are needed for site assessment and LWSC design. The U.S. Geological Survey's StreamStats program (water.usgs.gov/osw/streamstats/) provides estimated streamflow characteristics for any selected location on any mapped stream. StreamStats uses a geographic information system to determine the drainage area and other basin characteristics, and applies regional regression equations to estimate a variety of streamflow characteristics. Basin and streamflow characteristics provided by StreamStats include the drainage area, the flows exceeded 90%, 75%, 50%, 25% and 10% of the time (Q90%, Q75%, Q50%, Q25% and Q10%) the mean flow (\bar{Q}) and flows with recurrence intervals of 2, 5, 10, 25, 50 and 100 years (Q2, Q5, Q10, Q25, Q50 and Q100). Table 4-1 provides reasonable guidelines for classifying the stream as perennial, intermittent or ephemeral based on the StreamStats estimates of Q90% and Q10%.

Table 4-1: Guidelines for stream classification

Flow-duration estimates	Stream classification
Q10% > 0	Perennial
Q10% = 0 and Q90% > 0	Intermittent
Q90% = 0	Ephemeral

The representation of the stream on a USGS topographic quadrangle map (1:24,000 scale) also provides an indication of the appropriate classification. Stream segments considered perennial are shown as solid blue lines, stream segments considered intermittent are shown as dashed-and-dotted blue line, and stream reaches considered ephemeral are not shown on these maps

4.3. Frequency of Impassable Conditions for Unvented Ford

An unvented ford on a public road must be passable a very high percentage of time. The acceptable percentage of time for impassable conditions depends on the various considerations discussed in Chapter 2. An unvented ford is unsafe for vehicle passage when the depth of flow over the roadway exceeds 6 inches.

The percentage of time that the crossing would be impassable can be estimated by making a hydraulic calculation of the discharge at a 6-inch depth of overtopping (the maximum discharge for safe passage) and comparing this discharge to the StreamStats estimate for the discharge exceeded 10% of the time. For the unvented ford to be a workable option, the maximum discharge for safe passage should be much larger than the discharge exceeded 10% of the time (i.e., the crossing must be impassable much less than 10% of the time).

4.4. Hydraulic Requirements for Vented Fords and Low-Profile Box Culverts

Regional Condition 1 of the USACE Kansas City District imposes some hydraulic design requirements on stream crossings in Kansas and parts of Missouri (see Table 4-2). The full text of Regional Condition 1 can be found on the website of the USACE Kansas City District. This condition specifies minimum requirements for waterway openings for crossings on perennial, intermittent and ephemeral streams. Crossings on perennial streams should have a waterway area that equals or exceeds 85% of the preconstruction bankfull area. Crossings on intermittent streams should have a waterway area that equals or exceeds 50% of the preconstruction bankfull area. Crossings on ephemeral streams should be sized so that the geomorphic bankfull discharge does not overtop the roadway. The geomorphic bankfull discharge for ephemeral streams in Kansas can be estimated with regional regression equations developed by the University of Kansas (Young et al., 2014). KDOT's Design Manual, Volume I (Part C) provides useful

guidance for hydraulic analysis of culverts (also applicable to vented fords). The Federal Highway Administration's HY-8 computer program for hydraulic analysis of culverts is another useful tool.

According to Regional Condition 1, culvert pipes larger than 48 inches in diameter and box-culvert cells larger than 12.5 ft² in area must be embedded in the stream to a depth of 12 inches or greater to facilitate aquatic organism passage.

4.5. Flood Impacts

The replacement of a bridge with a low-water crossing can cause some increase or decrease in flood levels at and upstream of the crossing. The upstream effects may extend for some distance beyond the right-of-way. The design of a low-water crossing should always include a careful analysis of its impacts on changes in flood levels. A hydraulic analysis of the flood impacts is specifically required for a floodplain development permit or an individual stream obstruction permit.

Chapter 5

Case Studies

Nine stream crossings where low water crossings were constructed or considered have been included in this chapter. Eight of these LWSCs have been completed, and one has been delayed by regulatory issues. The estimated streamflow characteristic table for each case study was generated based on information from the Kansas Surface Water Register that is maintained by KDHE. The USGS Rural Regression Equations for the State of Kansas have been used to estimate peak watershed outflows.

5.1. Unvented Ford in Washington County

Location

This unvented ford is located on Fox Road approximately 1300 feet north of 12th Road at an unnamed tributary to Parsons Creek. This location is approximately 8 miles SW of Washington, Kansas. Latitude, Longitude: 39.7445°, -97.2562°

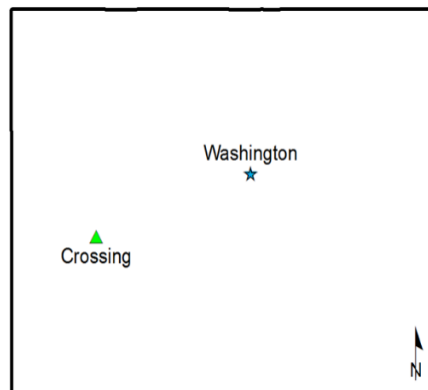


Figure 5-1: Location of crossing in Washington County



Figure 5-2: View of structure from upstream (left)

Figure 5-3: View of structure from downstream (right)



Figure 5-4: View of structure from road



Figure 5-5: Low-flow channel on the upstream side of the ford



Figure 5-6: View of channel upstream of ford (left)

Figure 5-7: View of channel downstream of ford (right)

Crossing Description

This unvented ford was completed in April 2014. The reinforced concrete slab is 60-feet long, 20-feet wide and 9-inches thick, and is underlain with six inches of aggregate base. Large cobbles protect the downstream face of the structure from erosion.

Crossing History

The previous structure was a 30-foot-long steel-truss bridge. The structure was over 90 years old and the area of the waterway opening under the bridge was only 51 ft² in 2014. The timber deck lacked structural integrity. Safety concerns with respect to structural integrity and frequent flooding lead to its removal.

Road and Traffic

Fox Road is owned and maintained by Grant Township. The road surface consists of compacted native soil. Farming vehicles and machinery use this crossing with limited usage for residential access. School buses and postal vehicles do not use this crossing which has an average daily traffic of fewer than 10 vehicles.

Stream Characteristics

The unnamed tributary to Parsons Creek is an intermittent-to-ephemeral stream. The drainage area at the ford is 1.9 mi². The channel bed is composed of silt, sand, and some gravel. The channel banks are composed of sand and silt. Minor aggradation is occurring in the vicinity of the crossing and soil is deposited over most of the ford's concrete surface. The bankfull channel is ten to twelve feet wide and two to four feet deep.

Table 5-1: Estimated streamflow characteristics at crossing

% of time flow is equaled or exceeded	Flow (cfs)		Recurrence Interval (years)	Flow (cfs)
90%	0		2	286
75%	0		5	662
50%	0		10	997
25%	0		50	1,950
10%	1		100	2,450

Governmental Permits and Regulatory Issues

This project required two permits: a Section 404 Nationwide Permit 14 issued by USACE and a Stream Obstructions General Permit issued by KDA-DWR. There were no concerns with nearby threatened or endangered species or items of historical significance. The unvented ford is located in a FEMA Zone A floodplain.

Structure Details

The paved crossing is constructed on a 100-foot vertical curve. The grades at the ends of the vertical curve are -11% and 12%. When an overtopping event occurs, the vertical curvature will keep the initial overflow on top of the ford as opposed to going around the slab. The structure was installed so that the lowest point on the roadway centerline matches the flowline of

the channel. The upstream and downstream faces of the concrete slab are protected by 60-foot long sheet-pile cutoff walls driven to a depth of 10 feet to prevent undermining.

Cost and Funding Source

The new ford was designed and constructed for a total cost of \$51,955. The lump-sum includes the design fee, earthwork, and materials. The cost of removing the old bridge is not included in this sum.

Maintenance Requirements and Performance to Date

The unvented ford has required little maintenance since its construction in 2014. When needed, accumulated debris is removed by a single person with a wheel loader in one to two hours. The road surfaces in the vicinity of the crossing have not required maintenance since the completion of construction. Washington County officials are pleased with the performance of the ford.

Project Owner

Washington County owns and maintains the crossing. The current project contact is Justin Novak, the Road and Bridge Supervisor.

Project Designer

CFS Engineers in Topeka, Kansas, designed the ford.

Summary

This unvented ford was part of a six-bridge replacement project in Washington County. A grant from the Community Development Block Grant program (CDBG) provided partial funding for this project. The crossing provides an example of a simple, low-cost solution at a

location where a bridge was not considered to be economically feasible. An unvented ford was chosen because the channel is shallow and the streamflow is usually minimal.

5.2. Hybrid Unvented Ford in Miami County

Location

The hybrid ford is located on an unimproved access road within the Hillsdale Lake Wildlife Refuge at an unnamed tributary to Little Bull Creek. This location is 0.2 miles south of 223rd Street and 0.9 miles east of Cedar Niles Road in Miami County, Kansas. Latitude, Longitude: 38.6875°, 94.8737°

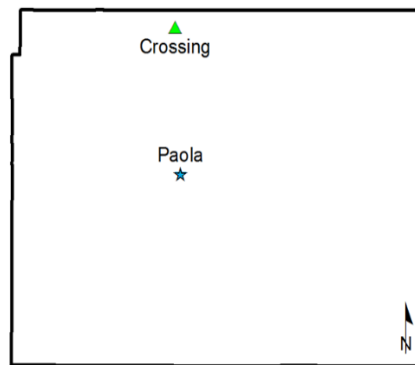


Figure 5-8: Location of crossing in Miami County



Figure 5-9: View of structure from upstream (left)

Figure 5-10: View of structure from downstream (right)



Figure 5-11: View of structure looking south (left)



Figure 5-12: View of submerged structure looking north (right)



Figure 5-13: View of upstream channel (left)



Figure 5-14: View of downstream channel (right)



Figure 5-15: Close-up view of the grated troughs (left)

Figure 5-16: Rock surface material on south approach (right)

Crossing Description

This hybrid ford, which was constructed in November 2009, provides access to cropland adjacent to Little Bull Creek and Hillsdale Reservoir. It is 16 feet wide with a 20 feet long center section and two 20-feet long approach sections. Both approach slabs have 7.5% slopes and the center section is horizontal. The roadway approach surfaces beyond the ends of the structure are surfaced with 6 inches of AB-3 surfacing material (gravel). Two grated troughs, each 30 inches wide by 12 inches deep, traverse the center slab. Juvenile fish can use the troughs for passage at low flows. These grates are removable so that the troughs can be easily cleaned as needed. This crossing is termed a hybrid unvented ford because the grated troughs have minimal hydraulic capacity but they provide pathways for aquatic organisms.

Crossing History

The previous structure was a bridge with a steel superstructure, a wood-plank deck, and concrete abutments. This crossing was closed after it was deemed unsafe due to broken timber floor-beams and extensive local abutment scour.

Road and Traffic

The Kansas Department of Wildlife, Parks and Tourism (KDWPT) owns and maintains the road and crossing. Agricultural vehicles and machinery use this crossing seasonally since this dead-end road provides the only access point for some cropland within the Hillsdale Wildlife area. This crossing is also used by Hillsdale Area personnel for emergency response to secluded areas within the refuge and for hiking, bird-watching, and photography.



Figure 5-17: Gate located in the parking lot off of W. 223rd St.

Except during periods of agricultural activity, the average monthly traffic is one KDWPT vehicle. Access to this road is controlled by a metal gate that is located in a gravel parking lot off of W. 223rd St. The 16-foot-wide road is constructed of compacted gravel and native soils but receives only minimal maintenance and is often overgrown with weeds.

Stream Characteristics

This crossing is located on an unnamed tributary 200 feet upstream of the confluence with Little Bull Creek. The contributing drainage area is 1.9 square miles. At times the crossing is flooded by backwater from Hillsdale Reservoir. According to the Kansas Water Office, the

water surface elevation of Hillsdale Reservoir is raised and lowered seasonally within a range of 2.8 feet to provide habitat for spawning fish populations and migratory birds. Water-surface elevations in the reservoir also increase for periods of time following precipitation over the upstream watershed. When Hillsdale Reservoir is high, backwater from the lake submerges the crossing, making it impassible. The channel bed and banks are mainly silt. In the vicinity of the structure, the bankfull channel is approximately 30 feet wide and 6 feet deep. The channel thalweg is approximately one foot below the structure's deck and 6 inches below the bottom of the grated troughs. Most of the upstream watershed is composed of pasture, cropland and woods. Table 5-2 shows a summary of estimated streamflow characteristics for the crossing.

Table 5-2: Estimated streamflow characteristics at crossing

% of time flow is equaled or exceeded	Flow (cfs)		Recurrence Interval (years)	Flow (cfs)
90%	0		2	562
75%	0		5	1,100
50%	0		10	1,540
25%	1		50	2,700
10%	2		100	3,290

The grated troughs are designed for fish passage; they are not sized to convey storm events. Vehicles cannot traverse this crossing during storm events or during periods of seasonal inundation.

Governmental Permits and Regulatory Issues

A Nationwide Permit #14 from USACE and a Stream Obstructions permit from KDA-DWR were obtained for this project. The crossing is located in a FEMA Zone A floodplain. A

hydrologic and hydraulic investigation was performed that showed that the structure would not increase the 1% annual chance flood level.

Structure Details

The crossing is an 8-inch-thick, 60-foot-long reinforced concrete slab. Eight-inch-thick, reinforced concrete cutoff walls were constructed for the entire slab length along both faces of the structure. The cutoff walls extend 4 to 5 feet into the streambed soil. Two 30-inch-wide by 12-inch-deep grated troughs are located in the middle of the structure.

The banks were re-graded to provide a gradual transition between the stream and the lowered road section. Eighteen-inch riprap was placed along both banks upstream and downstream of the structure. Channel areas upstream and downstream of the structure were excavated so that the riprap could be placed to protect against scour. Disturbed areas beyond the concrete and riprap-protected areas were stabilized with a native vegetation seed mix and biodegradable erosion-control blankets.

Costs and Funding Source

The total cost of the project was \$110,000, which includes design of the hybrid ford, demolition of the old bridge, and construction of the new crossing. Funding for this project was provided through The U. S. Fish and Wildlife Service as part of their Wildlife and Sport Fish Restoration Program.

Maintenance Requirements and Performance to Date

Hillsdale Wildlife Area personnel are satisfied with the performance of the crossing because it is usually passable and requires minimal maintenance. The crossing has not required routine maintenance after storms since its construction. Thus far, the structure has not accumulated

sufficient debris following a flood to impede vehicle access. If a trough were to become clogged with debris, it could be cleaned out easily by removing the top grates. When the lake elevation is high, water backs up in the stream channel over the crossing and is occasionally too deep to cross.

Project Owner

The Kansas Department of Wildlife, Parks and Tourism owns and maintains the crossing. Eric Kilburg, the Hillsdale Wildlife Area Manager, is the best point of contact.

Project Designer

This project was designed by Poe & Associates, Inc., in Topeka, Kansas.

Summary

This hybrid ford provides an example of a simple solution at a location where bridge replacement was not economically feasible. The public safety risk for this structure is minimal since the hybrid ford is used for seasonal field access, emergency response, and limited foot traffic by the general public. The grated troughs allow for aquatic organism passage and are easily accessible if cleaning is required.

5.3. Vented Ford in Kiowa County

Location

This structure is located on 21st Avenue at Mule Creek, 0.42 miles north of V Street.

This location is approximately 12.5 miles southwest of Greensburg, Kansas. Latitude, Longitude:
37.4314°, -99.3741°

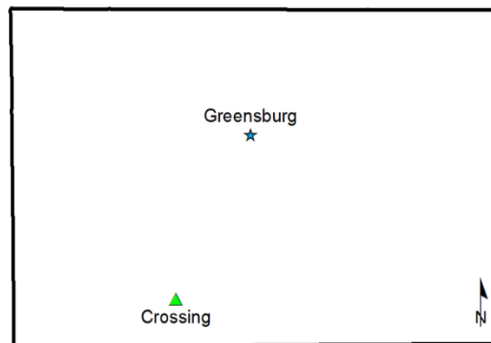


Figure 5-18: Location of crossing in Kiowa County



Figure 5-19: View of structure from upstream (left)

Figure 5-20: View of structure from downstream (right)



Figure 5-21: View of crossing from road



Figure 5-22: View of upstream channel (left)



Figure 5-23: View of downstream channel (right)



Figure 5-24: Washed-away aggregate stabilization on downstream left bank



Figure 5-25: Bank stabilization and silt accumulation on downstream side of structure

Crossing Description

This vented ford was completed in January 2015. It is 60 feet long and 28 feet wide and is constructed of reinforced concrete. Four 40-inch by 32-inch corrugated metal metal arch culverts (CMMAC) were installed at a 30-degree angle from perpendicular to the roadway so they would be aligned with the channel. The flowlines of the vents are embedded into the channel.

The height of the banks on both sides of the crossing are one foot higher than the structure's deck. The depth to channel bottom, on both sides of the crossing, is roughly 3.5 feet lower than the ford's deck.

Crossing History

The previous structure was a two-cell 11-foot-wide by 8-foot-high reinforced concrete box culvert. As shown in Figures 5-26 and 5-27, the old culvert was almost completely silted in and its deck was collapsed.



Figure 5-26: Old structure filled with sediment (left)

Figure 5-27: Partially collapsed culvert deck (right)

Road and Traffic

The 24-foot-wide county road is surfaced with compacted sand and gravel. Surrounding land uses include oil and gas pumping operations with some agricultural purposes. Heavy trucks carrying saline wastewater from oil and gas production and farm vehicles and machinery are the most common types of traffic. The ADT is less than 25. This crossing is not on a school bus route.

Stream Characteristics

The drainage area at a crossing of Mule Creek is 10.8 mi². The contributing drainage area is approximately half cropland and half rangeland. The streamflow is ephemeral. Table 5-3 shows estimated streamflow characteristics at the ford. The bed and banks are composed of silt and sand. The bankfull channel is 20 to 25 feet wide and 4 to 5 feet deep. In the vicinity of the crossing, the top-of-bank elevation is approximately 3.5 feet higher than the top of structure. Bank scars are present on the downstream side of the structure from recent flooding and localized road and farmland runoff as seen below in Figure 5-28.

Table 5-3: Estimated streamflow characteristics at crossing

% of time flow is equaled or exceeded	Flow (cfs)		Recurrence Interval (years)	Flow (cfs)
90%	0		2	394
75%	0		5	1,120
50%	0		10	1,840
25%	0		50	4,100
10%	0		100	5,360



Figure 5-28: Sedimentation and roadway erosion on top of downstream bank stabilization, taken from deck of structure

Governmental Permits and Regulatory Issues

This project required a Nationwide Permit 14 from USACE and a Stream Obstructions permit from KDA-DWR. The NWP included special provisions added by KDWPT. KDWPT required that the project not impact currently-listed threatened or endangered species, providing best management practices and construction recommendations to minimize disturbances.

KDWPT did not require the county to obtain a separate Action Permit, provided that construction began within one year and no design changes were made to the project plans. The crossing is located in an area that does not participate in the National Flood Insurance Program.

Structure Details

The reinforced concrete slab is 9 inches thick. The crossing is constructed on a vertical curve and the approaches are excavated and smoothed to acceptable grades. Reinforced concrete toe walls along the upstream and downstream faces of the structure extend below the top of the driving surface along the upstream and downstream faces of the structure. The toe walls are 8 inches thick and extend the full length of the structure. The vent pipes are spaced 2 feet apart, edge to edge, with one foot of concrete cover from the tops of the pipes to the roadway surface.

Cost and Funding Source

This crossing was constructed at a cost of \$60,000. This cost does not include engineering services.

Maintenance Requirements and Performance to Date

This vented ford has performed very well in its first year of operation. No debris removal or roadway resurfacing has been required. However, some riprap on the downstream side left bank has washed away and will need to be replaced with larger rock at some point.

Project Owner

Kiowa County owns the vented ford. Jay Schmidt, the Kiowa County Road and Bridge Supervisor, is the main point of contact.

Project Designer

Kirkham Michael Consulting Engineers in Ellsworth, Kansas, designed the project.

Summary

This ephemeral stream crossing is an appropriate location for a vented ford. This structure provides year-round passage for the heavy trucks that service the local oil and gas

production facilities. The embedded vent pipes allow for some degree of aquatic organism passage.

5.4. Vented Ford in Phillips County

Location

The vented ford is on West 1200th Road, 0.65 miles south of West Day Dream Road, at a crossing of Bow Creek, approximately 17.6 miles SW of Phillipsburg. Latitude, Longitude: 39.5725°, 99.5528°

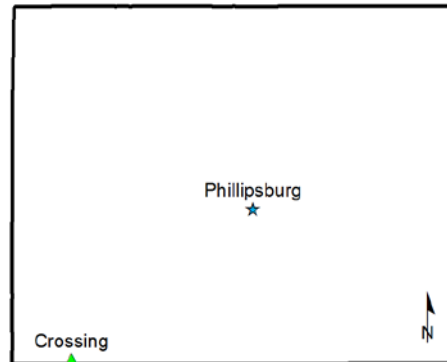


Figure 5-29: Location of crossing in Phillips County



Figure 5-30: View of structure from upstream (left)

Figure 5-31: View of structure from downstream (right)



Figure 5-32: Facing south toward structure (left)



Figure 5-33: Facing north toward structure (right)



Figure 5-34: Upstream channel taken from the deck of structure (left)



Figure 5-35: Downstream channel taken from deck of structure (right)



Figure 5-36: Timber buildup on the upstream face of structure



Figure 5-37: Buried steel H-pile on the upstream face of structure (left)



Figure 5-38: Exposed H-pile on downstream face of structure (right)



Figure 5-39: Upstream channel (left)



Figure 5-40: Downstream channel (right)

Crossing Description

The vented ford was constructed in 2007. The ford crosses Bow Creek and is made of concrete with three 36-inch diameter corrugated steel pipes. The concrete deck is 6 inches thick. The pipes are 50 feet long and are rotated 30 degrees from perpendicular with the surface of the crossing so they are in line with the channel thalweg. This vented ford is 20 feet wide with approach grades of -2.2% and 3.6% at the ends of the vertical curve. Both approach slabs are 20 feet long and the center slab is 15 feet long.

Crossing History

The previous crossing was a 50-foot-span bridge with a steel-truss frame and a 16-foot wide deck. The old bridge was no longer in service because it had become structurally deficient over time and was completely collapsed down in the riverbed. The newly constructed vented ford benefitted county residents by providing an accessible crossing.

Road and Traffic

West 1200th Road is made of sand and native soil with a 16 to 18-foot width. Phillips County owns and maintains the roads and structures. The traffic types on 1200th Road are primarily passenger vehicles, farming equipment, and oil-field traffic. The ADT for West 1200th Road in the vicinity of the crossing is less than 10 vehicles and is not used by school buses or as a postal route.

Stream Characteristics

Bow Creek, a tributary to the N. Fork Solomon River, is a perennial stream that is upstream of Kirwin Reservoir. The contributing drainage area at the crossing is 279 mi². The land use in the watershed is primarily pasture with some cropland. Bow Creek's channel bed soil is comprised of silt and sand and the banks are primarily silt. The channel widths near the

crossing varies from 25 to 35 feet. The right bank of the channel is less than one foot above the bridge deck. The left bank is one to two feet higher than the bridge deck. Timber and silt-laden debris are commonly seen in Bow Creek.

The vent pipes are perched above the channel with flowlines 1.5 feet above channel bottom on the upstream side and 3 feet above the channel bottom on the downstream side. The channel thalweg immediately downstream of the culvert is 3 feet lower than the pipe's flowline indicating the formation of a scour hole, which obstructs aquatic organism passage at low flows.

Table 5-4: Estimated streamflow characteristics at crossing

% of time flow is equaled or exceeded	Flow (cfs)		Recurrence Interval (years)	Flow (cfs)
90%	0		2	779
75%	1		5	2,470
50%	2		10	4,380
25%	4		50	11,200
10%	8		100	15,400

Governmental Permits and Regulatory Issues

A NWP #14 from USACE and the stream obstructions permit from KDA-DWR was obtained for this project in 2007. However, the permitting constraints were different in 2007 because there were no requirements to embed culverts that exceed a certain size of waterway opening. This vented ford would not be permitted under current regulatory requirements. This vented ford is not located in a community that participates in the National Flood Insurance Program.

Structure Details

The vented ford has three 36-inch CMPs with 2-feet spacing between pipes. The depth from the top of deck to the top of the CMPs is approximately 1 foot.

Costs and Funding Source

The total cost of the project was \$34,500. This cost includes materials and design. Phillips County was able to save money by using county forces to complete the construction portion of the project.

Maintenance Requirements and Performance to Date

Since the crossing was built in 2007, it has required little maintenance. Phillips County is very satisfied with how this crossing is operating. Following flood events the county uses a two-man crew to perform maintenance. This maintenance usually involves using a backhoe to remove woody debris from the upstream face. The process usually takes an hour to complete.

Project Owner

The vented ford is owned and maintained by Phillips County. Rick Capps, the Road and Bridge Supervisor, is the main point of contact.

Project Designer

Penco Engineering, P.A. in Plainville, Kansas designed the vented ford.

Summary

This vented ford provided an economical solution for the passenger vehicles, farming equipment, and oil-field traffic that rely on this crossing location. Regulatory requirements have changed since this structure was permitted and constructed in 2007. Current regulations would require a structure with larger vents embedded a foot or more below the channel bottom to facilitate aquatic organism passage.

5.5. Proposed Vented Ford in Osborne County

Location

The proposed vented ford will be located on West 120th Drive at a new crossing of Twin Creek. This location is 0.6 miles east of S. 70th Avenue, approximately 5.5 miles SE of Osborne, Kansas. Latitude, Longitude: 39.3944°, 98.6090°

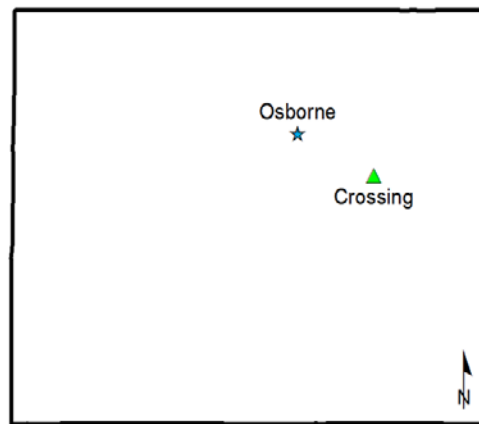


Figure 5-41: Location of crossing in Osborne County



Figure 5-42: Old steel-truss bridge, which was closed in June 2015



Figure 5-43: Right abutment retrofitted with steel sheet-pile (left)

Figure 5-44: Left abutment with original wood planks (right)

Crossing Description

The existing steel-truss bridge on West 120th Drive has been closed since June 2015 due to structural and functional deficiencies and the expense of required periodic inspections. The bridge is too narrow for some modern farm vehicles and machinery, and its abutments are failing. The structure is a 54-foot-span steel-truss bridge with a roadway width of 16 feet. The bridge deck is 12 to 14 feet above the channel thalweg. Osborne County had planned to remove the old bridge that was built in 1905 and replace it with a vented ford until a Section 404 permit review by USACE found that the bridge could be historically significant. After consultation with the Kansas State Historical Preservation Office (SHPO), the bridge's historical significance was confirmed. A study by USACE, SHPO, and Osborne County examined whether the bridge could be preserved, restored, or relocated. These options were found to be impractical.

Osborne County is now considering realigning the roadway so that it crosses Twin Creek 400 feet upstream of the old bridge. The current plan is to abandon the existing roadway and remove the old bridge. The new roadway will have two 12-foot lanes within a realigned right-of-way. The proposed replacement structure is a ford with an 84-inch diameter CMP vent embedded to a depth of one foot. The crossing would be constructed within a 300-foot vertical

curve. If constructed, this new crossing would provide easier access for large farming equipment and machinery to nearby cropland.

Road and Traffic

West 120th Drive is owned by Penn Township and is constructed of native soil. The proposed realigned roadway would be 24 feet wide. The road and crossing is used as a through route for agricultural purposes. Farming equipment and passenger vehicles used the crossing when it was open. West 120th Drive is expected to have a future ADT of 10 vehicles or less. The existing bridge is currently closed and the proposed crossing will not be used by school buses or as a postal route.

Stream Characteristics

Twin Creek is an intermittent stream with a drainage area of 61 mi² at the crossing. Estimated streamflow characteristics for the crossing are shown in Table 5-5. The land usage in the watershed is primarily agricultural. The streambed and banks are mostly silt. The banks are heavily vegetated with trees and brush. Where the new vented ford has been proposed, the bank height is 12 to 14 feet. The stream's low-bench and high-bank widths are approximately 15 and 30 feet.

Table 5-5: Estimated streamflow characteristics at crossing

% of time flow is equaled or exceeded	Flow (cfs)		Recurrence Interval (years)	Flow (cfs)
90%	0		2	824
75%	0		5	2,280
50%	1		10	3,780
25%	3		50	8,660
10%	7		100	11,400

Governmental Permits and Regulatory Issues

A NWP #14 from USACE and a Stream Obstructions Permit from KDA-DWR have been obtained for this project. Osborne County does not participate in the National Flood Insurance Program. USACE, in conjunction with KDWPT, found there were no concerns with nearby threatened or endangered species or their critical habitats.

USACE is the responsible federal agency for the implementation of Section 106 of National Historic Preservation Act (NHPA). This project required a permit to comply with Section 404 of the Clean Water Act (NWP 14). The 404 permit allows an historical review in accordance with NHPA. Because the steel-truss bridge was built in 1905, USACE determined that this structure is eligible for listing in the National Register of Historic Places and SHPO concurred with this determination. To mitigate the loss of the steel-truss bridge, Osborne County developed a mitigation plan in consultation with USACE and SHPO that requires the preservation and nomination of two steel-truss bridges to the National Register of Historic Places, where preservation is defined as leaving the bridge in place. Two other steel-truss bridges in Osborne County will be preserved and nominated to the National Register. The mitigation plan will allow Osborne County to remove or repair seven other steel-truss bridges, including the closed bridge on W. 120th Drive.

Lessons Learned

The demolition and construction project has not yet begun due to permitting constraints. Osborne County Public Works believes that earlier communication with USACE, SHPO and nearby landowners would have helped prevent costly delays in the project.

Cost and Funding Source

As of May 2016, Osborne County had obtained the necessary permits to remove the closed bridge on West 120th Drive, realign the roadway, and install a low-water crossing. Complications related to right-of-way acquisition have delayed the project. The Kansas Local Bridge Improvement Program at KDOT will provide funding to remove the old bridge.

Project Owner

Osborne County will own and maintain the crossing that will replace the deficient bridge. Bo French, the current Road and Bridge Supervisor, and Larry Patee, the former Road and Bridge Supervisor, are the contacts for the project.

Project Designer

Penco Engineering, P.A. in Plainville, Kansas, designed the vented ford.

Summary

This project has multiple interesting facets that make it a worthwhile case study. This project is a great example of a large, deficient, but historically important bridge being potentially replaced by a low-water crossing. To obtain the required permits to replace the old bridge, Osborne County worked with USACE and SHPO to develop an acceptable replacement plan. Input from the general public was a part of the process. Osborne County worked directly with USACE and indirectly with SHPO to determine which bridges are eligible for the register. USACE and Osborne County then solicited public comments to help determine which bridges should be removed or rehabilitated. Based on their experience, county officials recommend communicating with applicable permitting agencies and nearby land owners early in the planning process.

5.6. Low-Profile RCB in Shawnee County

Location

The low-profile, two-cell RCB is located on NW 46th Street, 0.50 miles west of Capper Road, at a crossing of a tributary to Cross Creek. This structure is located in the Kansas River floodplain, approximately 1.1 miles southwest of Rossville, Kansas. Latitude, Longitude: 39.1296°, -95.9707°

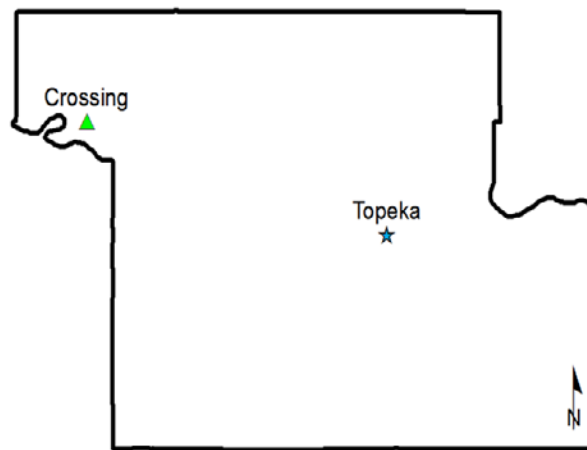


Figure 5-45: Location of crossing in Shawnee County



Figure 5-46: View of structure from upstream (left)

Figure 5-47: View of structure from downstream (right)



Figure 5-48: NW 46th Street looking west toward structure (left)

Figure 5-49: NW 46th Street looking east toward structure (right)



Figure 5-50: Upstream wingwall with riprap stabilization covered in silt (left)

Figure 5-51: Downstream wingwall with riprap stabilization (right)



Figure 5.6.8 (left): Upstream channel from top of structure (left)

Figure 5.6.9 (right): Downstream channel from top of structure (right)



Figure 5-52: Upstream channel taken immediately upstream of the culvert (left)

Figure 5-53: Downstream channel taken immediately downstream of the culvert (right)

Crossing Description

The box culvert has two cells, each 10 feet wide by 6 feet high, with a total length of 67 feet. Shawnee County found that lengthening the culvert to provide 4-foot-wide shoulders on the roadway over the structure was a cheaper alternative to keeping the road width constant since it would not be necessary to install bridge railings. In addition to increasing construction and materials costs, bridge railings tend to catch debris and become damaged during an overtopping event. When the debris catches on railings it can clog the waterway opening, which can lead to

overtopping and diversion of flow around the structure. Railings on narrow bridges also can hinder or prevent the passage of large farming and agricultural vehicles and machinery. The RCB is aligned with the channel at a 32° angle from perpendicular to the roadway.

The construction of the low-profile RCB began in October 2013 and was completed in November 2013. The weather and working conditions were ideal at this time of year and the channel was completely dry. The contractor used 32 of the 53 calendar days allowed for road closure prior to reopening for traffic.

Crossing History

The previous structure was a 15.7-foot-long simple-span bridge. The deck, backwalls and piling were made of timber. The roadway was 19 feet wide with guardrails that required frequent maintenance due to damage from debris and farming equipment. The area of the waterway opening was only 86 ft², significantly smaller than the new structure's 120-ft² waterway area. The new box culvert is slightly embedded so the waterway area has minor fluctuations.

Road and Traffic

NW 46th Street is owned and maintained by the Rossville Township and the crossing structure is maintained by Shawnee County. The road surface is covered with compacted gravel underlain by native soil. NW 46th Street has an average width of 15-16 feet. The width of the road increases to 24 feet over the new structure and for several hundred feet on both sides of the crossing. This crossing is primarily used by farming and passenger vehicles. The RCB is surrounded by several square miles of cropland with few residents.

The previous bridge had an ADT of 10 vehicles. County engineering staff stated that the ADT has increased to nearly 50 after the culvert improvement was completed. Since the new

crossing has a wider roadway surface and no railings, large agricultural vehicles and machinery can now use NW 46th Street rather than Highway 24.

Stream Characteristics

This tributary of Cross Creek is an agricultural drainage channel on a straight alignment. The streamflow is intermittent. Backwater from high flow in the Kansas River can occasionally fill the tributary. Table 5-6 shows estimated streamflow characteristics. The drainage area at the crossing is 2.8 mi². The watershed is composed entirely of cropland within the Kansas River floodplain.

Table 5-6: Estimated streamflow characteristics at crossing

% of time flow is equaled or exceeded	Flow (cfs)		Recurrence Interval (years)	Flow (cfs)
90%	0		2	536
75%	0		5	1,130
50%	0		10	1,640
25%	1		50	3,030
10%	2		100	3,740

The stream is approximately 7 feet deep with a bankfull width of 25 to 30 feet at the natural channel cross-sections. The channel bed and bank soils are primarily silt. The stream carries large volumes of silt at high flows.

This tributary experiences backwater from the Kansas River during periods of high flow. The backwater effect on this stream leaves lots of areas with ponded water in the channel, which supports a healthy habitat for many types of aquatic and terrestrial species. The University of Kansas research team observed numerous frogs during the June 2016 site visit.

Governmental Permits and Regulatory Issues

Shawnee County Public Works obtained a NWP #14 from USACE and a stream obstructions permit from the KDA-DWR before starting construction. This remove-and-replace project had no issues with threatened or endangered species or historical or archeological resources. This crossing is located within the regulatory floodplain of the Kansas River (Zone AE). A CLOMR/LOMR was not required.

Structure Details

The 67-foot-long RCB has roughly one foot of fill on top of the concrete deck for the road surface. Approach grades for the roadway are minimal. The culvert openings are aligned with the channel. The horizontal alignment is skewed 32 degrees from perpendicular to the roadway. The RCB has wing walls at 45° angles to the culvert that support the roadway embankment and protect the structure from scour.

Riprap is placed on the left bank of the channel on the upstream and downstream sides of the culvert for protection against scour and erosion. When the RCB was installed, it was placed one foot below the normal streambed elevation and backfilled with one foot of native streambed soil to promote aquatic organism passage.

Cost and Funding Source

The construction cost was \$150,000. The total project cost, including design, inspection and staking, and some minor right-of-way acquisition, was approximately \$195,000.

Maintenance Requirements and Performance to Date

The structure has not required routine maintenance since it was built in 2013. During a period of high flow in the Kansas River in 2014, the crossing was submerged and some of the roadway was damaged by erosion and silt deposition. The Township of Rossville re-surfaced and

smoothed NW 46th Street shortly after this flood. Otherwise the crossing has performed very well, with no significant erosion or sediment deposition around or within the culvert.

Project Designer

The project was designed by Finney and Turnipseed Transportation and Civil Engineering L.L.C.

Project Owner

Shawnee County Public Works owns and maintains the crossing. The main contact for the project is Mike Welch, P.E., at Shawnee County Public Works.

Summary

This low-profile culvert is part of an initiative to replace several deficient bridges in Shawnee County. These RCBs are different from a typical RCB constructed on a paved road because the deck does not have railings and it is installed at a lower profile. The increased RCB length allows for a wider roadway without railings that facilitates the passage of agricultural vehicles and machinery.

5.7. Low-Profile Bottomless Culvert in Johnson County

Location

Two bottomless culverts are located on 175th Street in an unincorporated area of Johnson County, Kansas. The east structure is located approximately 300 feet west of Mission Road on Camp Branch Tributary A. The west structure is located approximately 1600 feet west of Mission Road on Camp Branch Creek. This case study focuses on the west structure over Camp Branch Creek. Latitude, Longitude: 38.8111°, 94.6369°

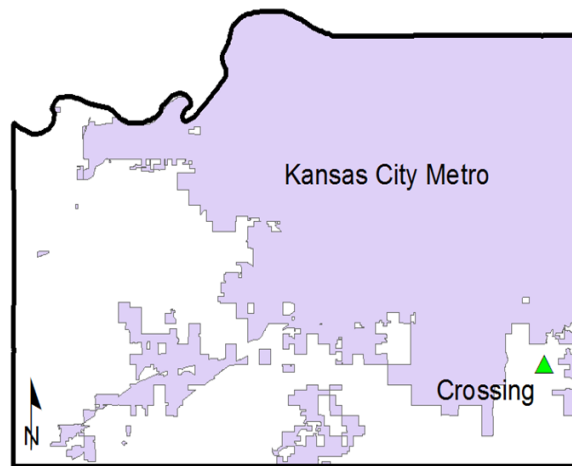


Figure 5-54: Location of crossing in Johnson County



Figure 5-55: View of structure from upstream (left)



Figure 5-56: View of structure from downstream (right)



Figure 5-57: 175th Street looking east toward structure (left)



Figure 5-58: 175th Street looking west toward structure (right)



Figure 5-59: West abutment looking upstream (left)



Figure 5-60: East abutment showing exposure of stem wall looking upstream (right)



Figure 5-61: Upstream channel from top of structure (left)



Figure 5-62: Upstream channel at a point 70 feet upstream of the structure (right)



Figure 5-63: Downstream channel from top of structure (left)



Figure 5-64: Downstream channel at a point 40 feet downstream of structure (right)



Figure 5-65: Downstream face of the bottomless culvert, east abutment (left)



Figure 5-66: Downstream face of the bottomless culvert, west abutment (right)

Crossing Description – West structure over Camp Branch

The 3-sided bottomless culvert was constructed in 2010. The waterway opening is 20 feet wide. The opening height above the natural channel bottom ranges from 5.6 feet to 6.9 feet at the upstream face and 5.4 feet to 6.3 feet at the downstream face. The reinforced concrete driving surface is 124 feet long and 21 feet, 4 inches wide.

Crossing History – West structure over Camp Branch

The previous structure was a vented ford with three 24-inch CMPs, as shown in Figures 5-67 and 5-68. The previous crossing on 175th Street over Camp Branch Creek was too often impassable due to overtopping and also impeded aquatic organism passage.



Figure 5-67: Upstream face of previous structure (left)

Figure 5-68: Downstream face of previous structure (right)

Road and Traffic – West structure over Camp Branch

The approaching road surfaces are made of compacted gravel and native soil and are owned and maintained by Johnson County. The posted speed limit for 175th Street is 35 miles per hour. Unlike typical low-water crossings, the structure is used regularly by a variety of vehicles including residential, industrial, commercial, and agricultural traffic types. More specifically, the road is used as a distributor road which serves to move traffic to arterial roads. According to Johnson County, the average daily traffic count is about 300 vehicles. However, the ADT is expected to increase significantly with development in the surrounding area. During the academic year, the crossing is used by school buses and as a postal route year-around.

Stream Characteristics

Camp Branch Creek is an intermittent stream with a bedrock channel bottom with loose cobbles on top. The channel banks are composed primarily of silt with rock outcroppings. Upstream of the crossing, Camp Branch Creek has an average upstream width of 35 feet and main-channel depth of approximately 6 feet from thalweg to top of bank. Downstream of the

crossing, the main channel is approximately 55 feet wide with a depth of 8 feet from thalweg to top of bank. The downstream channel has a well-defined low bench area that is approximately 30 feet wide and 3 feet deep from thalweg to top of bench.

The drainage area at this crossing is 6.8 mi². The land use in the watershed is a mix of low-density residential properties, cropland, pasture, and woods. Table 5-7 shows estimated streamflow characteristics for Camp Branch Creek.

Table 5-7: Estimated streamflow characteristics at crossing

% of time flow is equaled or exceeded	Flow (cfs)	Recurrence Interval (years)	Flow (cfs)
90%	0	2	1,210
75%	0	5	2,420
50%	1	10	3,430
25%	4	50	6,150
10%	10	100	7,530



Figure 5-69: Minor lateral migration has occurred, threatening the stability of trees on the upstream east channel bank (left)



Figure 5-70: Bank scar on east upstream bank, which has rock outcroppings (right)

Governmental Permits and Regulatory Issues

The bottomless culvert is located in a FEMA Zone AE with a regulatory floodway. The applicant did not obtain a CLOMR and LOMR from FEMA since a no-rise condition was maintained. A Flood Plain Development Permit was obtained from the Johnson County Planning, Development, and Codes Department. A stream obstructions permit from KDA-DWR was also obtained for this project since the contributing drainage area was greater than 1 square mile. No Kansas Department of Wildlife and Parks permits or special authorizations were required. There was no loss of Waters of the United States since a low water crossing was replaced with a bottomless culvert. Therefore, the U.S. Army Corp of Engineers did not require a Section 404 permit.

Structure Details

The precast bottomless culvert is 20 feet wide and is supported by spread footings. The stream substrate is bedrock, which lends itself to the use of a structure on spread foundations since the channel bottom is less prone to vertical degradation. The footings are keyed into shale approximately 3 feet below the streambed. The western and eastern ends of the pavement approach transitions are approximately one-half of a foot higher than the bridge overtopping elevation. During an overtopping event, water initially flows over this concrete pavement rather than around the ends.

Costs and Funding Source

Multiple options were evaluated to determine the most reasonable and economical solution for this location. The county received a \$65,000 grant from the U.S. Fish and Wildlife Service to replace the old vented ford with a fish-friendly bottomless structure. The total construction cost in 2010 was approximately \$127,000. This projected cost included mobilization of equipment,

removal of existing structures, channel excavation, the precast bridge structure, the precast footings, precast installation, riprap volume, concrete pavement, seeding with site restoration, traffic control, and erosion and sediment control.

Maintenance Requirements and Performance to Date

Since the crossing's construction in 2010, it has required very little maintenance and has been performed well. A few large storms have caused a need for minor debris removal and cleaning. This maintenance takes a two-man group with chainsaws and a dump truck an entire day to complete. The roads in the vicinity of the crossing are usually resurfaced with gravel every four years. The new structure traps much less debris and require less maintenance than the old structure.

Project Owner

Johnson County owns and maintains the crossing. Ayman Issawi of Johnson County Public Works and Infrastructure is the main point of contact for this project.

Project Designer

Johnson County Public Works (JCPW) designed the crossing with help from the U. S. Department of Fish and Wildlife Service.

Summary

This project is interesting for multiple reasons. This segment of 175th Street has a higher ADT and a wider variety of traffic types than a typical low-water crossing. For this reason, multiple options were evaluated to determine the most reasonable and economical solution for this location. A detailed hydraulic study was required to verify that the structure met the no-rise condition in a FEMA Zone AE floodplain and floodway. JCPW received a grant from U.S. Fish and Wildlife Service to remove a vented ford that behaved like a dam and replace it with a crossing that was more conducive to fish passage. The new crossing is safer than the previous structure

because it overtops less frequently. The bottomless culvert is expected to be a temporary structure that will likely be replaced by a safer open-span bridge within the next 15 years when 175th Street is improved.

5.8. Low-Profile Open-Span Bridge in Sumner County

Location

This structure is on S. Chicaskia Road at Bluff Creek, 0.5 miles north of the Kansas-Oklahoma border. The crossing is approximately 1.3 miles east and 1.7 miles south of Caldwell, Kansas. Latitude, Longitude: 37.0063°, 97.5824°

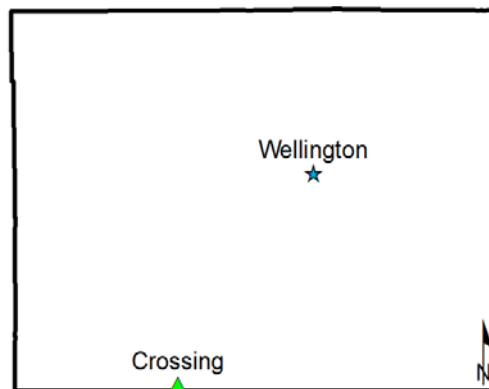


Figure 5-71: Location of crossing in Sumner County



Figure 5-72: View of structure from upstream



Figure 5-73: View of structure from downstream



Figure 5-74: View of structure from road



Figure 5-75: View of upstream channel from crossing



Figure 5-76: View of downstream channel from crossing



Figure 5-77: View of downstream bridge face in comparison streambank height (left)

Figure 5-78: View of upstream bridge face in comparison to streambank height (right)



Figure 5-79: Road approach facing north from structure (left)

Figure 5-80: Road approach facing south from structure (right)



Figure 5-81: Debris-catching piers on the upstream side of bridge

Crossing Description

This low-profile open-span bridge was constructed in October 2007. The steel bridge has four 25-foot spans. Three piers extend 8 feet upstream of the bridge deck to catch woody debris before it reaches the bridge deck. These extended piers help keep the bridge deck clear from timber debris, reduce the risk of damage to the upstream side of the structure, and increase the flow capacity under the bridge. The approaches are constructed of compacted rock, native soil, and some asphalt. Approach grades are -9.1% and 6.0%. After a high-flow event, the captured debris is removed from the piers and bridge deck and placed on the downstream bank, away from the creek. Wing walls made of sheet piling, on the north and south ends of the structure, extend tens of feet into the riverbanks to prevent flood waters from washing away the approaches. The south end of the structure is especially prone to erosion and the wing walls extend up to 100 feet into the stream bank. The wing walls were driven to a depth of three feet below the streambed. Riprap is used to prevent local erosion of the approaches.

Crossing History

The previous structure was a vented ford with five 72-inch corrugated steel vent pipes. Reinforced concrete headwalls and wing walls protected the structure. The upstream and

downstream sides of the structure were sloped to help pass debris over the structure during high flows. On the upstream side the CMPs were mitered flush with the sloping headwall. On the downstream side the CMPs extended a few feet beyond the sloped edge of the structure. A large difference between the streambed elevation and the top of deck elevation and timber-laden flow were the main reasons the old structure had to be replaced. The roadway surface was approximately 10 feet higher than the streambed elevation. The old structure was replaced because its vents were often clogged with large woody debris, which caused frequent flooding of the roadway and on one occasion caused the south approach to wash out.



Figure 5-82: View of downstream side of old structure (left)

Figure 5-83: Washed-out south approach to old structure (right)



Figure 5-84: Looking north on S. Chicaskia Road at washed-away approach

Road and Traffic

Caldwell Township owns and maintains the road which is made of compacted native soil. Land use in the watershed is primarily agricultural. Farming vehicles, agricultural machinery and passenger vehicles use this bridge regularly. This crossing is not on a school-bus route. Average daily traffic for this bridge is less than 15 vehicles.

Stream Characteristics

Bluff Creek is a perennial stream. Bluff Creek is prone to lateral migration. The drainage area at the crossing is 442 mi². The streambed is composed of clay, silt and gravel. In the vicinity of the crossing the bankfull channel is 13 to 15 feet deep and 110 to 130 feet wide. The banks are made clay and silt and are heavily vegetated. Table 5-8 shows the estimated streamflow characteristics at the crossing.

Table 5-8: Estimated streamflow characteristics at crossing

% of time flow is equaled or exceeded	Flow (cfs)		Recurrence Interval (years)	Flow (cfs)
90%	4		2	5,890
75%	10		5	12,500
50%	23		10	18,500
25%	53		50	36,000
10%	132		100	45,200

Governmental Permits and Regulatory Issues

Sumner County obtained a NWP #14 from USACE and a stream obstructions permit from KDA-DWR for this project. The permittee was allowed to install a temporary crossing during construction of the bridge. There is a Zone AE floodplain with a floodway upstream of the structure and a Zone A floodplain on the downstream side of the structure. The dividing line of this change from a detailed delineation (Zone AE) to a zone that is mapped by approximate methods (Zone A) appears to be the centerline of Chicaskia Road. This project reduced flood levels upstream of the crossing. This remove-and-replace project had no issues with threatened or endangered species or historical or archeological resources.

Structure Details

This four-span low-water bridge is 102 feet long and 24 feet wide. The bridge deck sits on W12x50 steel girders. The bridge deck is cast-in-place concrete on top of steel decking. Steel pipe piling support the piers, bridge deck, and approaches. The concrete deck is 8.5 inches thick. Wing walls made from sheet-pile extend into the stream banks, are installed 3 feet below the streambed level to prevent erosion of the approaches.

Cost and Funding Source

The cost of the materials for the bridge, not including wing walls, was approximately \$70,000. Sumner County removed the old crossing and built the new bridge with county forces in approximately one month.

Maintenance Requirements and Performance to Date

The debris-capturing extended piers have performed very well. Sumner County has yet to have any major timber-debris problems that required closure of the bridge. The county plans to replace another problematic vented ford with a low-profile open-span bridge of the same general design.

Sumner County removes trapped debris with an excavator with a jaw attachment. The woody debris is placed on the side of the channel downstream of the bridge, where it is burned by Caldwell Township. Debris removal typically takes one to three hours.

Project Owner

Sumner County owns and maintains the bridge. Melvin Matlock, the Road and Bridge Director, and Nita Simonton, the Supervisory Engineer, are the main project contacts.

Project Designer

The Sumner County Engineering Department designed the crossing with assistance from CFS Engineers in Topeka, Kansas.

Summary

This low-profile bridge in Sumner County is an interesting project for several reasons. The structure is simple, relatively inexpensive, and it was constructed by county forces. Bluff Creek carries a heavy debris load at high flows. The low-profile bridge traps much less debris than the old structure and allows for aquatic organism passage. Approaches are protected from

wash-out by extensive sheet-piling. The previous structure, a vented ford, became clogged, the stream migrated around the end of the structure and destroyed the south end approach, rendering the road impassable. Replacing the previous ford with a low-profile bridge helped enable the stream to flow more freely and reduced the risk of clogging.

5.9. Low-Profile Single-Span Bridge in Geary County

Location

The crossing is on Pressee Road at McDowell Creek, 0.5 miles east of McDowell Creek Road. This location is approximately 4 miles SE of Ogden, Kansas. Latitude, Longitude: 39.0699°, 96.6479°

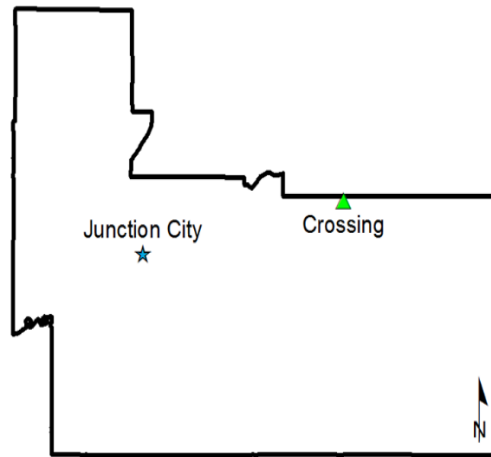


Figure 5-85: Location of crossing in Geary County



Figure 5-86: View of structure from upstream (left)

Figure 5-87: View of structure from downstream (right)



Figure 5-88: View of structure from Pressee Road



Figure 5-89: Upstream right bank (left)

Figure 5-90: Upstream left bank (right)



Figure 5-91: Downstream right bank erosion from flood waters (left)

Figure 5-92: Comparison photo of the same bank taken eight months earlier (right)



Figure 5-93: Upstream channel taken from the bridge deck (left)

Figure 5-94: Downstream channel taken from the bridge deck (right)



Figure 5-95: Left bank, looking upstream, taken from the downstream channel (left)

Figure 5-96: Right bank, looking upstream, taken from the downstream channel (right)

Crossing Description

This single-span low-profile bridge was constructed in 2015. The bridge deck is 46 feet long, 14.5 feet wide, and 2 feet thick. The precast concrete bridge deck rests on concrete abutments supported by steel H-piles. The bridge deck is approximately 7 feet lower than the top of the channel banks. The bridge was placed below the channel banks to reduce its length for economy.

Crossing History

The previous structure was a 79-foot-long steel-truss bridge with a 16-foot-wide deck. The old bridge was closed in January 2014 when county inspectors noticed several broken deck planks. The deck of the old bridge was approximately 14 feet higher than the deck of the new bridge.

Road and Traffic

Pressee Road is a dead-end gravel road that provides the only access for three agricultural parcels with no residences. The bridge is exclusively used for agricultural purposes. The ADT is minimal.

Stream Characteristics

McDowell Creek has a drainage area of 65.7 mi² at Pressee Road. Table 5-9 shows estimated streamflow characteristics for this location. The watershed is three-fourths pasture with some cropland and woodlands. The mean annual precipitation is 34 inches per year. The banks are heavily vegetated with some minor evidence of lateral migration. The channel is 80 to 100 feet wide between tops of banks.

Table 5-9: Estimated streamflow characteristics at crossing

% of time flow is equaled or exceeded	Flow (cfs)		Recurrence Interval (years)	Flow (cfs)
90%	0		2	4,740
75%	2		5	9,810
50%	8		10	14,300
25%	27		50	26,700
10%	76		100	33,000



Figure 5-97: Scouring on the upstream right-bank wing wall with newly applied aggregate on the approach and edge of the bridge deck to combat erosion

Governmental Permits and Regulatory Issues

This project required two permits. A Section 404 Nationwide Permit 14 (Linear Transportation Projects) was issued by USACE, and a Stream Obstructions General Permit was issued by KDA-DWR. The KDA-DWR Permit required the structure to pass the 2-year discharge without overtopping. Because the crossing is located in a FEMA Zone A floodplain, the structure could not increase the 100-year flood level by more than one foot. No issues with threatened and endangered species or historical or archaeological resources were raised.

Structure Details

This single-span bridge is constructed of precast concrete. Each abutment is constructed of cast-in-place concrete on four HP10x42 steel piles driven to shale. Construction plans indicate that all piles were to be driven to a depth of 16.5 feet. A geotechnical investigation was performed to estimate the necessary depths for the piles. The abutments are protected by 24-inch light-series stone riprap along the upstream wing walls. The channel banks on both sides of the bridge are protected with 24-inch riprap. Because the bridge deck is approximately 7 feet below the tops of the channel banks, it was necessary to excavate nearly 4,000 cubic yards of soil was to achieve acceptable approach grades.

Cost and Funding Source

The total bridge cost was \$251,375. This cost includes engineering, surveying and construction management. Geary County received \$120,000 for this project from KDOT's Kansas Local Bridge Improvement Program.

The unpaved approaches are stabilized with shot-rock and aggregate. County personnel indicate that if the crossing were in a different location with a higher ADT, then the approaches

would be made out of concrete to decrease erosion and maintenance and enhance traction and safety at the crossing.

Maintenance Requirements and Performance to Date

Since the new bridge was completed in March 2015, the approaches have needed to be resurfaced with aggregate four times. After the first flood event caused minor scouring around the wing walls, the county placed 24-inch rock around the upstream wing walls for protection.

Cleaning off the bridge and reapplying aggregate usually takes a two-man crew 1 to 2.5 hours. Large timber debris is removed from the bridge and placed downstream with a back-hoe with an extended arm and hydraulic thumb.

Project Owner

Geary County, Kansas owns and maintains the crossing. Dennis Cox, Geary County Public Works Director, is the main point of contact.

Project Designer

Kaw Valley Engineering, Inc. in Junction City, Kansas designed the bridge.

Summary

This sturdy and economical structure carries heavy trucks and machinery across a large stream. The new structure was constructed at a much lower elevation than the old bridge to reduce its length. Because its deck is considerably lower than the tops of the channel banks, the bridge is overtopped frequently and requires removal of trapped woody debris and repair of the unpaved approaches. This design is appropriate for the requirements of this location. This large crossing with a precast-concrete deck was constructed in only three weeks.

Chapter 6

Lessons Learned

This section of the thesis states some opinions of the people who provided insight on their experiences with LWSCs. Helpful design, construction, and permitting information is presented. Several engineers, county officials, and permitting agencies provided personal experience with LWSCs that contributed to this portion of the report.

According to the counties surveyed, roughly one-half of Kansas counties and their officials favored LWSCs. Many counties in Kansas have LWSCs even if the current county engineer or road supervisor did not approve of the crossing type. Wood's thesis in 1984 reported that 89 of 105 Kansas counties have at least one LWSC. This figure has probably not changed much.

6.1. Permitting Input

- Obtaining the necessary permits for LWSCs is accomplishable but may not always be easy.
- Most counties in Kansas participate in the National Flood Insurance Program. In these counties, LWSC projects require a floodplain development permit from the local floodplain administrator. FEMA flood maps should be reviewed in the planning stages of the project.
- Attempting to permit a LWSC in a FEMA-designated floodway will cause permitting delays and may rule out certain types of LWSCs.

- The permitting process requires input from some agencies which have a history of causing project delays.
- KDWPT recommends that county officials considering a LWSC project should discuss the project with KDWPT before applying for any permits. Early communication can prevent project delays during the design and construction phases.
- KDWPT prefers unvented fords over vented fords and will always recommend designs that promote aquatic organism passage.
- KDWPT does not object to LWSCs in general because they understand the tight budgets that most counties have. However, KDWPT often puts restrictions on the times of year when the crossings can be built.
- KDWPT understands that the majority of LWSCs are placed on roads with very low ADT and are in remote locations. The small streams on which most LWSCs are constructed usually have a riffle-pool complex that supports small aquatic species. KDWPT will perform a site visit to the project location if time permits.
- KDA-DWR and USACE usually do not check engineering calculations but instead refer to Regional Condition One described in previous chapters. LWSCs are viewed differently than a typical culvert or bridge.
- USACE considers the physical characteristics of the stream during the Section 404 permit review and is concerned with backwater conditions.
- Both KDA-DWR and USACE have a history of refusing to permit LWSCs for various reasons.

6.2. Design, Construction and Cost Input

- Local opinion from county officials plays a large part in how the LWSC is designed and what type is used. For example, a county engineer's experience in the same stream at different locations can provide helpful insight into what type and depth of foundation to use.
- The stream crossing types upstream and downstream of the project location can help guide the choice of crossing type.
- LWSCs should be installed on a flat slope within the channel and with mild approach grades. Streams that are wide and shallow are good locations for LWSCs.
- If a vented ford with multiple vents is being considered, installing the vents at slightly different elevations can improve aquatic organism passage.
- Aluminum box culverts have been chosen to replace structurally deficient concrete box culverts because they are resistant to corrosion and are lighter structures. Lighter structures are easier to transport and put in place.
- LWSCs can be installed quicker than a typical high-profile bridge or culvert.
- Low-water crossings should always be designed with the bankfull width in consideration. Paving the approaches longer than the bankfull width will keep the ends from washing out.
- Some counties choose to use LWSCs despite the risk of safety to the traveling public.
- Some county engineers will only use low-water crossings on dirt roads used only for agricultural access.
- Flowing water, silt, timber, and ice on a LWSCs surface can all pose threats to safety.

- Proper road signage can improve the safety of a LWSC. It is paramount to inform drivers that the road is prone to flooding.
- The higher safety risk of an LWSC can be outweighed by the need to replace a structurally or functionally deficient bridge. Many farm vehicles and machines are very wide and too heavy for old steel-truss bridges with timber decks.
- County officials agree that LWSCs are cheaper to construct than high-profile bridges and culverts but the costs of frequent maintenance should also be considered.
- Some counties use a rock ford with a CMP vent as a cost-effective solution for an agriculture crossing that is used only by a nearby landowner for field access.
- For LWSCs, no size and type will fit all stream locations. Each LWSC must be designed with site-specific details in mind because every location is different.
- Engineering design fees add to the project's total cost.
- Some counties prefer not use LWSCs because they require a lot of maintenance and have limited lifespans.
- Siltation and timber debris can cause ongoing maintenance problems in certain stream locations. Maintenance can become costly over time.
- Most types of LWSCs require substantial foundations to keep them in place.
- The length of a LWSC is always a difficult decision. If the paved approaches are too short the ends of the approaches may get washed out and undermined. However, longer approaches will cost more money.
- The size of the vents is an important design decision, but any size of vent may become clogged with debris.

- Most common problems with LWSCs occur at the approaches. During high flows the approaches may get washed out to some extent. On the downstream side of the structure, high flows can create a scour hole, which leads to the vents becoming perched, impairing aquatic organism passage.
- Maintenance of a LWSC on a large river can be difficult and costly.
- LWSCs require maintenance at least a couple times annually. Timber can cause damage to the upstream sides of LWSCs if not properly protected.
- In the planning phases of the project, the engineers and county officials must take into account the remoteness of the project location. Some crossing types and materials require large machinery and it can be difficult for certain types of construction equipment to access a remote and heavily wooded area on narrow roads.
- Bottomless culverts may not be the best structure type. If a headcut is traveling upstream toward the crossing, a bottomless structure will not stop the headcut from continuing upstream. When the headcut reaches the bottomless structure it can cause severe scour and erosion around the foundation.
- Some counties prefer to not accept the safety risks of LWSCs and spend the extra money on a more substantial structure.
- Accident liability is a concern with LWSCs. LWSCs are built without guardrails and are designed to be flooded at times. When the roadway is flooded, it is difficult for drivers to tell the depth of water over the road. It would be better and safer to use an alternative route. For this reason, a LWSC should never provide the only access for residents.
- Some county officials think the initial costs of LWSC installation are generally underestimated.

- Many counties cannot afford the hydraulic investigation that some crossing locations would require.
- The maintenance requirements for an LWSC can deter some counties from using LWSCs even though they may cost less initially.
- Inspections are required for all bridges on public roads. The costs of inspecting a fracture-critical bridge was cited as a common reason to pursue LWSCs as an economically viable alternative.

Chapter 7

Conclusions

From the work presented in this report we draw the following conclusions:

- 1) The planning phase of the project should include consideration of: available funding, risk to safety, traffic volume and type, aquatic organism passage, hydrology, horizontal and vertical alignment, woody debris load, and maintenance requirements.
- 2) The regulatory agencies responsible for permitting LWSCs recommend contacting them early in the planning phases of a project. Early communication will help the permitting process go smoother and avoid delays later in the project.
- 3) The permitting agencies view LWSCs differently than a conventional bridge and culvert. The permitting agencies generally understand that most counties cannot afford to replace bridges with like structures on very low-volume roads.
- 4) From extensive communication during this research, we found that LWSCs are often a feasible and less expensive alternative to replacing a bridge or closing down the county road.
- 5) LWSCs are generally impractical for deeply incised channels. On incised streams, the top of the stream bank can be much higher than the ordinary high water mark (Young et al, 2014). Installing LWSCs in deeply incised channels can require extensive excavation to achieve acceptable approach grades.
- 6) LWSCs are best utilized in stable channels with light to moderate debris loads at high flows.

- 7) LWSCs work well, with minimal safety risk, where the crossing is used only for agriculture access and not for residential access.
- 8) Signage is an important component on a road with a LWSC. Proper signage on a roadway that is prone to flooding will improve safety.
- 9) After high-flow events, every LWSC within the county should be inspected and debris should be removed and re-apply roadway surface material as needed.

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